STUDIES IN LIFE-HISTORIES OF AUSTRALIAN DIPTERA BRACHYCERA.

Part i. Stratiomyiidae.

No. 1. *Metoponia rubriceps* Maequart.

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(Plates xxvii.-xxviii., and 23 text-figures.)

Introduction.

During the past twelve months I have had the opportunity of collecting, in the neighbourhood of Sydney, many soil-inhabiting dipterous larvae, belonging, for the most part, to the section Brachycera. Of these, I have succeeded in rearing through to the imago, species of the families *Stratiomyiidae, Mydaidae, Tabanidae, Asilidae, Therevidae,* and *Bombylidae,* and to the pupal stage, many other, as yet unidentified, species.

Very little work has been done, in any part of the world, on the early stages of the Brachycera, and the Australian forms have been, up to the present time, almost entirely unknown. The material now collected is therefore of considerable importance, as affording an opportunity of studying the life histories of these flies. Many gaps yet remain to be filled. In no case has it been possible to observe all stages in the development, but it is hoped that the preliminary study of the data obtained will prove useful as a basis for later, more extensive, investigations. The present paper is intended as the first of a series dealing with the biology of the group, arranged in the order of the families.

The *Stratiomyiidae,* usually placed by taxonomists at the beginning of the Brachycera series, are of special interest because of the peculiar, intermediate position which they occupy, in their mode of development, between the two great sub-orders of Diptera, distinguished by Brauer under the names *Orthorrhapha* and *Cyclorrhapha.*

Although classed with the Orthorrhapha, and developing a more or less perfect "pupa obtecta," they pass the entire pupal period within the last larval skin, which constitutes a hard, protective case, recalling the "puparium" of the Cyclorrhapha. And the opening up of this case, at the emergence of the fly, is in the form of a combination of the straight dorsal split of the Orthorrhapha, and the anterior circular split of the Cyclorrhapha.

A discussion of the significance of these characters is outside the scope of the present work. But the *Stratiomyiidae* have been taken first, both on account of the usually accepted position of the family, and because the abundance and accessibility of the material makes possible a fuller investigation of the life-history of one of this group, than is the case with the majority of the other families studied.

I wish here to acknowledge my indebtedness to Mr. G. H. Hardy, who is at present engaged on the taxonomic study of the species, *Metoponia rubriceps* Macq. with which this paper deals. It was his observation and identification of the fly in Sydney, in 1919, which afforded me the opportunity of studying its life-history, and I owe to him many helpful suggestions, and assistance with systematic work and with literature. I have also to thank Mr. C. Hedley, Acting Curator of the Australian Museum, for the facilities afforded me at the Museum for carrying out the investigation; and members of the Museum staff, generally, for their constant helpfulness during the progress of the work. To my mother I owe the preservation of living larvae over a period of two months, when, through illness and an enforced absence from Sydney, I was unable to attend to them myself. For the execution of Plate xxvii., in collaboration with myself, I have to thank my friend, Miss Edith Horrocks.

Historical.

At the end of this paper I append a list, with accompanying bibliography, of all the species of *Stratiomyiidae* which have been recorded in the early stages. The latest list of this kind, of which I am aware, was published by Brauer in 1883, nearly forty years ago. In addition to being now very much out of date, its value is impaired by the incomplete way in which the references are quoted, and the lack of dates, and of a bibliography. Nevertheless, I have found it of great service, in the preparation of a revised and more up-to-date list, and have taken from it many references which I have had no opportunity of seeing elsewhere. The bibliography, which I have added, has been extended to cover, as far as possible, all works dealing in any way with the biology of the *Stratiomyiidae*. Here again I have been obliged to rely on earlier workers, and on catalogues such as those of the Royal Society and the British Museum, and the Zoological Record, for many references, since a large part of the literature quoted is not available to me. But I have endeavoured to make it as accurate as possible by a comparison of records in the various catalogues. Arranged in chronological order, and with explanatory notes, it forms in itself a brief historical review of all the work done to date on this subject. In appearance this is of considerable bulk, but its scope is limited. Certainly, more attention has been paid to the early stages of the *Stratiomyiidae* than to those of any other family of the Brachycera. Stratiomyid larvae seem to be plentiful in most parts of the world, and very often live under conditions which excite interest, or where they are readily found. But in many instances the reference to them consists merely of a record of their occurrence, and habitat, with or without a brief description of the larva. Thus Packard (1871), Lucas (1879), and Griffith (1882) note their occurrence in the salt water, and hot water of lakes and springs; Pearson (1882), the finding of a larva on a very exposed part of an ocean beach, Florentin (1899), a great mass of them in excessively saline pools in Lorraine, Markel (1844), their association with a nest of ants. The larvae which have been most frequently recorded and described are those living in water, especially the genera *Odontomyia* and *Stratiomyia;* and of these the species *Stratiomyia chamaeleon* L. has received the most attention. Being easily obtainable, these species have been used by workers engaged in a study of the comparative anatomy of the larvae of various insects, notably by Kunckel d'Herculais (1879), and Viallanes (1882 1885). But the descriptions have been, as a rule, confined

to special organs, and no attempt has been made to give a general and complete account of the larval morphology and the metamorphosis of any of the *Stratiomyiidae*. Portions of the nervous system have been described, in this way, by Kunckel d'Herculais (1879), Viallanes (1882, 1885), and Henneguy and Binet (1892); the integument, by Leydig (1860), Viallanes (1882), and Plotnikow (1904); the malpighian vessels, by Vaney (1900); the pharynx, by Vaney (1902) and Jusbaschjanz (1910), and the head and mouth parts, by Becker (1910). The most important work on the development is that of Jusbaschjanz (1910), who deals in great histological detail with the development of the imaginal discs, etc.; but he gives no account of the general metamorphosis. He explains that such an account would require a much richer material than he had at his disposal at the time, and that he had not succeeded in getting many pupal stages, the few pupae he obtained being all in the later phases of development. He proposes to deal more completely, in a later work, with the phenomena of metamorphosis and development; but, if the promised work has appeared, it has not been accessible to me, and I have found no record of it in the catalogues. I have not seen Swammerdam's book (1737), but, according to Jusbaschjanz, he describes the metamorphosis of *Stratiomys chamaeleon* with an accuracy remarkable in such an early work. Good descriptions of the external features of larvae exist in various papers dealing with individual species; but the most important works, from a systematic point of view, are those of Brauer (1883), and Lundbeck (1907). Although Brauer deals with dipterous larvae in general, his work is very comprehensive in character. After discussing the value of larval characters in classification, and the metamorphosis of the different groups, he gives a section on the characters of the sub-orders and families, followed, in the case of the *Stratiomyiidae*, by a systematic table (p. 23) of the larval characters of the different genera. Lundbeck, in his valuable work on Danish Diptera, supplies a description of the larvae under the heading of each genus of the *Stratiomyiidae*, and finishes with a synoptic table (p. 74) of the larvae of all Danish genera.

Little or nothing is known of the life-histories, or even of the larvae, of the Australian *Stratiomyiidae*. The only published record of the early stages of any of this group, which I have been able to find, is that of Froggatt (1896), which relates to *Ephippium albitarsis* (?) Bigot.

Observations on the life-history of *Metoponia rubriceps* Macq.

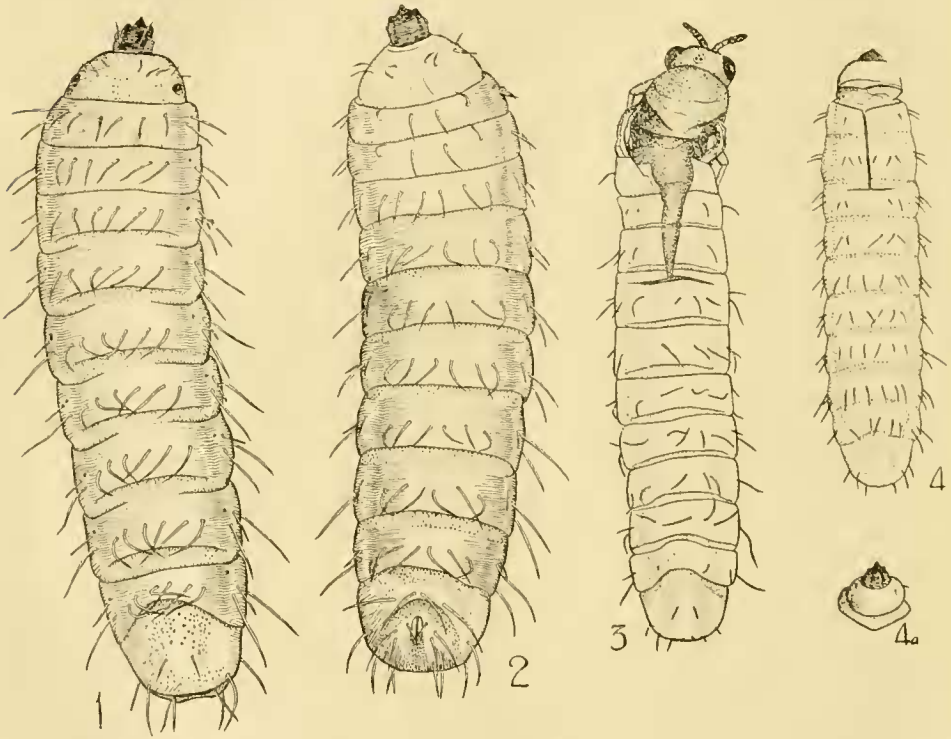
For a few weeks in the spring, and again in the autumn, this species makes its appearance, in fairly considerable numbers, over grassy areas in the neighbourhood of Sydney. Well cultivated lawns seem to be specially favoured haunts, and the flies, which are small, with feeble powers of flight, are usually found on, or about, the grass. They seldom rise far above the ground, though in the autumn of this year, one female specimen was captured on a window of the third floor of the Australian Museum. Like most Stratiomyids, they are sluggish in their habits, and remain for long periods at rest on the grass blades, where they are easily caught by inverting a glass tube over them. Mr. G. H. Hardy informs me that he has taken specimens from the middle of March to the end of April, and in the early part of November, but has never seen them at other times of the year.

The present investigation into the life-history was begun in May, 1919, when I received from Mr. Hardy a specimen tube containing a cluster of eggs on a grass blade, with the information that they were deposited by *Metoponia rubri-*

ceps within a few hours of her capture on the morning of the 16th April. Owing to an accidental delay in transmission, they did not reach me for nearly three weeks, during which time they had become shrivelled and dry, and, though kept undisturbed for another month, they failed to hatch out.

Attempts to secure further batches of eggs, by confining the two sexes in breeding cages containing grass sods, all proved unsuccessful. It was found that the flies, for the most part, remained motionless in the one position from the time they were put into the cage until their death, a period varying from three to ten days; and no case of oviposition was observed.

In the following November Mr. Hardy directed my attention to the reappearance of *M. rubriceps* on a grass plot behind the Australian Museum, with the suggestion that this might prove a natural breeding ground for it.



Text-fig.1. Larva of *Metoponia rubriceps* Macq. Dorsal view. (x 10).
Text-fig.2. .. .. Ventral view. (x 10).
Text-fig.3. *M. rubriceps*. ♀ emerging from larval skin. (x 6⅓).
Text-fig.4. *M. rubriceps*. Empty larval skin of ♂. (x 6⅓).
Text-fig.4*a*. Detached 'head cap' of larval skin. (x 6⅓).

Here a small sloping bank thirty feet long by twelve feet wide, in the middle of an asphalted courtyard, has been formed by laying down sandy black loam, to a depth of one to two feet, on a rubble foundation of broken bricks and stones, and planted with paspalum and couch grass, interspersed with dandelion plants and other weeds. It is kept well tended, and always contains a fair

amount of moisture, so that the grass grows well, with thick rhizomes and closely matted roots.

On the 7th November a small portion of this turf was dug up, and a search made for larvae in soil spread out over a white concrete path. Together with numerous Hymenopteron and Coleopteron larvae, and some cocoons of wasps, and Syrphid flies, some twenty-eight larvae were found, of an undoubtedly Stratiomyid type, ranging in size from 5 to 11 mm. (Text-figs.1 and 2). Fourteen of these were kept alive, and confined together in a small cylindrical glass pot, containing an inch or two or soil, and some small grass sods, and covered with a glass lid. As the grass decayed, fresh sods were put in at intervals of two or three weeks, and a few drops of water added with them, so that the soil was kept just slightly damp. Five months later most of the larvae were still alive, but showed very little increase in size.

On the morning of the 13th April a male *Metoponia rubriceps* was found to have emerged. This date corresponded closely with that on which the flies had been observed first on the Museum lawn in the previous year. Accordingly, on the following morning, a visit was paid to the spot from which the larvae had been taken. Here, large numbers of imagines, both males and females, were found already out, swarming above the grass in fairly rapid flight, the unusual activity being due, probably, to a period of warm sunshine following several days' rain. From Mr. Hardy I learnt that a few individuals had first appeared a week or two before, but that they had not become numerous until within a few days of this time.

Larvae were found to be present in the soil in much greater numbers than had been observed in the previous November. A rough search through turf taken from an area less than two feet square revealed eighty-five larvae, in all stages of development, from larvae 3.2 mm. long, to fully developed pupae in larval skins 8 to 11 mm. long. Two female imagines were found just in the act of emerging, and were killed and fixed in this position, half way out of the larval skin (Text-fig. 3). These were both taken just at the surface of the soil. In the same position, among exposed rhizomes, were many empty cases, all showing a clean-cut, circular, aperture at one end, and measuring from 7 to 11 mm. long. In several instances the anterior extremity, forming a lid-like cap to the case, was still lightly attached to it on the ventral side (Text-fig 4), but broke away with the slightest movement (Text-fig. 4*a*).

The vertical levels, in the soil, from which larvae of different sizes were obtained, were carefully noted. The fully grown larvae were all found almost on the surface, about the junctions of stems and roots, mostly wedged in between the thicker rhizomes, especially of the paspalum grass. In colour, and segmented appearance, these bear a rather striking resemblance to the larvae. From this level, down to one to two inches below the surface, fifty of the larger larvae were taken. At a slightly lower level, three to four inches down, among the finer grass rootlets, were smaller larvae, always in close association with the grass. Several were found attached by the head-capsule to roots, and one, removed from the soil with its head buried in the root of a dandelion plant, remained in this position for several hours. About eighteen inches below the surface, the sub-soil and rubble foundation of the lawn were reached. No larvae were found at, or below, this depth, and only a very few at the ten-inch level. These last were of medium size, from 5 to 8 mm. long.

For the next two or three weeks flies continued to emerge in the large glass jar, containing grass sods, in which these larvae were confined. They made their appearance successively on the 19th, 23rd, and 30th April, and 3rd and 4th May. With the exception of two females on the 23rd, these were all males. By this time most of the remaining larvae of the larger size had been chloroformed and dissected. Some twenty of them were found in various stages of pupation within the larval skin; the rest still retained the unaltered larval structure.

On the 30th April, a second imago, a male, emerged from among the larvae collected in the previous November. These two are the only ones of this collection which have emerged to date (September, 1920). Six of the larvae are still alive, but none of them show any signs of pupating as yet.

After an interval of one month, on the 13th May, the Museum lawn was again examined. Imagines were now very scarce, only one male and two females being observed. There was a corresponding scarcity of mature larvae in the soil, but numerous empty larval skins were found on, or close to, the surface. In the deeper levels, among the terminal rootlets of the grass, smaller larvae were still plentiful. Over forty were collected in a few spadefuls of earth, the smallest of them being barely 2 mm. long, while others ranged up to 6 and 7 mm. A few larger larvae were found closer to the surface. Of these, three were found to contain female pupae, two of them being dead, and already beginning to decay. From a fourth, a dead and dried, but fully-formed male imago was taken.

It seemed evident that the smaller larvae belonged to one or several younger generations which were burrowing down to pass the winter at deeper levels, as the mature larvae migrated to the surface to pupate. But it was necessary to follow them up, later on in the winter, in order to find out just what had become of them. Accordingly, on the 3rd August, another examination of the lawn was made. On this occasion the soil was very damp after five or six weeks' continual rain, and only a small area of ground, about the size of the surface of the spade, was dug up. No larvae were found close to the surface, but eighteen, varying in size from 5 to 11 mm., were found among the terminal rootlets, at a depth of three or four inches, four larvae, from 5 to 8.5 mm., a little lower down, and three from 7 to 8.5 mm. at a slightly greater depth.

It will thus be seen that larvae of very varying sizes occur at all periods of the year, and that except when they are about to pupate, most of the larvae are found always at a depth of two or three inches below the surface.

Living larvae of all sizes, from 4 to 9 mm., and of all collections, from November onwards, are still being kept under observation, though a good many have died or been lost, owing to the predations of rats and mice, which infest the laboratories of the Macleay Museum, and appear to have developed a taste for fly larvae. On several occasions glass pots left overnight uncovered, or with loosely-fitting covers, have been found in the morning with the soil overturned, and all the larvae gone.

Life-cycle.

Fargeau and Serville, as early as 1825, quoting Macquart's description of *Pachygaster ater*, made the statement that the larvae require more than a year for their complete development. And Westwood (1840) says that the larva of *Clitellaria ephippium* found by Van Roser, although more than half-grown when found, was two years in arriving at the perfect state. Later writers appear to have paid very little attention to this question of the period occupied in the life-

cycle of any of the *Stratiomyiidae*. Most of them content themselves with rather vague statements, as, for instance, that "the larvae hibernate, and development takes place in the spring and summer." Tragardh, in his description of *Pachygaster minutissima* (1914) makes the observation that during the summer only small larvae can be found, from which fact the deduction is drawn that only one generation is produced annually, which hibernates in the larva-stage, conforming to the account given by Perris (1870) concerning *Pachygaster pini*. Cros, in his interesting observations on the larval habits of *Stratiomyia anubis* (1911), records that, of a dozen larvae collected on the 22nd October, 1903, four yielded imagines in the following June, while from twenty-six larvae collected on the 31st December, 1909, five flies were obtained successively on the 25th June, and on the 4th July, 1910. But he gives no account of the fate of the remainder of the larvae.

None of the larvae of *Metoponia rubriceps* have grown very much during their period in captivity, and some time must elapse before it is possible to determine the normal time occupied in larval development. However, it is already clear that, although two broods of flies appear annually, the larval period requires more than six months for its completion, and very probable that it requires considerably longer than twelve months. This may be deduced from the very slow growth of larvae in captivity, and the fact that larvae, already more than half-grown when taken in November, show no sign of pupating in the following September. Although it is not safe to arrive at definite conclusions from larvae kept under abnormal conditions, these conclusions are borne out by observations in the field, since small larvae are found at all times of the year, and larvae less than 5 mm. long five months after the last appearance of the adult flies. The smallest larva found, being only a little more than twice the size of the egg, was probably still in the first larval instar when taken, one month after the appearance of the imagines. It seems reasonable to assume that larvae of this, and perhaps the 3 and 4 mm. length, hatched from the egg during the season in which they were taken.

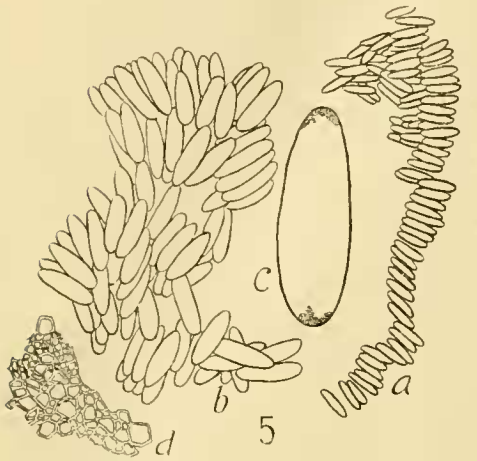
Unfortunately, no eggs were found in natural conditions, and, though several batches were obtained from females captured in glass tubes during the past autumn, none of them hatched out.

Various methods of keeping them were adopted—on damp blotting paper over a layer of damp soil, in a covered glass pot; on growing rhizomes of paspalum grass; directly on damp soil; or kept in the tube in which they were deposited. In most cases they were covered up from the light, and care was taken to prevent them from becoming completely dry. Under dry conditions they soon shrivelled up, while, when conditions were at all damp, the eggs were continuously thickly coated with fine beads of moisture, and many of them were found to be infested with fungus after a short time. However, a fair number retained their normal shape and appearance for ten weeks or more, but in no case did they show any sign of development. It is possible that all these eggs were infertile.

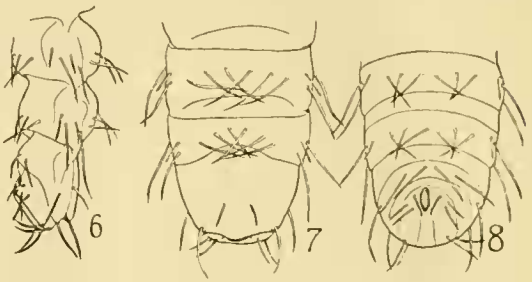
Oviposition.

Gravid-looking females taken during the morning, between 10 and 11 o'clock, usually oviposited very rapidly, the egg-laying being finished before midday. Usually the eggs were laid on the side of the glass tube, sometimes on cotton-wool. In one instance they were placed in a single, fairly even row, along the

side of the vessel, adhering to one another laterally, and to the vessel by means of a sticky substance with which they are coated (Text-fig. 5*a*). But all the others laid in tubes, as well as those obtained in the single instance in which one female oviposited on soil in a breeding cage, formed one or two clumps, the eggs being piled up irregularly on one another, though often remaining in contact at the pole (Text-fig. 5*b*).



Text-fig.5. *a*, Egg cluster *M. rubriceps*. (x 5); *b*, egg cluster. (x 10); *c*, single egg. (x 32); *d*, sculpturing on chorion of egg. (x 193).



Text-figs.6–8. Posterior end of larva of *M. rubriceps*.
Fig.6. Lateral view. Fig.7 Dorsal view. Fig.8. Ventral view. (x 10).

The number of eggs deposited, in each case, by four females was carefully counted. The numbers were, respectively, 130, 163, 164, and 181. If these figures represent anything like the normal number, the fecundity of this species is much lower than is the case with *Stratiomyia chamaeleon* Deg., for which Mik (1896) gives the figure 636.

The Egg.

The eggs are opaque white in colour, and elongated oval in outline, slightly broader at one end than the other (Text-fig. 5*c*). They measure from .80 to .88 mm. in length, and .22 to .27 mm. in diameter. The chorion is thin, and its surface shows a very delicate sculpturing in the form of an irregular network of raised lines enclosing polygonal-shaped spaces (Text-fig. 5*d*). This marking can only be seen under high magnification, and when the chorion is torn away, or freed from the internal contents of the eggs by clearing. Treatment with caustic potash, or with clearing agents, such as clove and cedar oil, did not give good results, but more success was obtained when the eggs were immersed in chloroform, and afterwards cleared in xylol. They then mounted fairly well in Canada balsam.

Ecdysis.

I have been unable to determine the total number of ecdyses occurring during the larval period. Only one of the larvae kept in the laboratory has been observed to moult twice, once on the 3rd December, and the second time on the

8th June, when 8.2 mm. long. A single moulting occurred in a number of cases among the larvae taken in April and May. The majority of these were at the 7 mm. stage, but there were a few at 6, 8, 9, and 9.5 mm. Whether these lengths represent successive instars, there is not yet sufficient evidence to prove.

All the larvae escape from the old skin in much the same way. Before moulting the skin becomes dry and withered looking, much softer than when functional, and a lighter colour. The process, which usually occupies about an hour, begins by a splitting of the moult skin, along one side, from the third to the ninth or tenth segment, the larva slowly moving from side to side, and contracting. The skin of the anal region remains intact, and that of the anterior end is split off entire, between the third and fourth segments. Frequently the larva emerges from the posterior portion with its head still enclosed in this anterior "cap," which is subsequently shed. The empty moult skin stands out stiffly, retaining the same size and shape as when the larva is still enclosed in it.

The new larval skin is a delicate white or creamy colour, its surface flecked with glistening particles, and showing the typical hexagonal pattern very distinctly. It assumes a brownish tinge only very slowly, and is still light in colour at the end of several weeks. Older larvae show the more normal grey-brown colour, which tones very well with the soil in which they live. The coating of particles of dirt which invests most of them increases this resemblance to their environment.

Pupation.

During the period of pupation the larval skin becomes much darker, and assumes a dry, rigid appearance, by which the condition is easily recognised, although there is no change in outward form. Larval skins of male pupae measure from 7 to 8 mm., those of females from 10 to 11 mm. For some time before the emergence of the adult fly the pupating larva is quite motionless, and to all appearances dead. One found in this condition on the 13th April, did not emerge until the 30th April, so that the pupal stage occupies at least eighteen days. This is a longer period than is given by Jusbaschjanz, who states that the pupal stage lasts eleven to thirteen days.

Larval habits.

The larvae are all extremely sluggish in their movements. Usually they remain quite immobile for five or ten minutes after being disturbed; then begin slow movements of contraction, and, if lying ventral side uppermost, roll over, and crawl slowly and stiffly along, seeking to take cover beneath the soil, a process which occupies half an hour or more. On a hard surface, or a layer of soil too thin to burrow into, their rate of progression is of the order of 5 to 10 mm. in ten minutes. Larvae confined in glass pots in the laboratory are usually found wedged among the roots of grass soon after the fresh sods are put in with them, and sometimes adhering to a root by the head capsule. It is evident that their main, if not only, source of nourishment is in the juices of the living plant. But I have never been able to detect any scars, or perforations, or other evidences of injury on the roots, and, even where the larvae are very numerous, the grass which harbours them shows no ill-effects from their presence. While living normally in soil in which a fair degree of moisture is present, they are able to sustain life in much drier conditions. Individuals left for twenty-four hours or more, without soil, in a dry Petri dish, showed no ill-effects from the experi-

ence. Others, covered with a thin layer of sandy soil, which, owing to evaporation, soon became quite dry, were still alive, and quite healthy after several days. But larvae which had been placed in small porous flower pots, planted with grass, were found quite dead, dry and shrivelled, together with the grass, when, owing to a week's enforced neglect, the soil had been allowed to become dry and caked hard. Returned to damp conditions none of them showed any signs of reanimation. In their powers of resistance to desiccation, therefore, they are strikingly different from the aquatic species of *Stratiomyia* observed by Cros (1911), and by Laker (1880). The former records having kept larvae of *Stratiomyia anubis* in a phial containing 15 mm. depth of completely dry sand for seven months before the emergence of the imago. And Laker found a living larva of a *Stratiomyia* sp. in the dry sand at the bottom of a box formerly used as an aquarium, after it had been emptied of water, and stored in a cellar for fully three months.

Description of the larva.

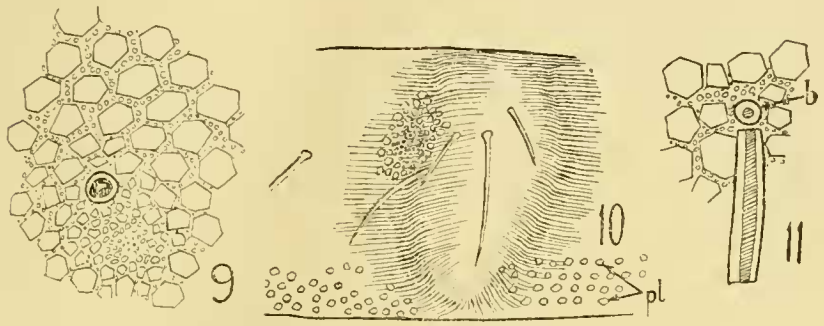
The larvae are very similar in general appearance to those of the genus *Sargus* Fabr., as described by Brauer (1883), and Lundbeck (1907). But the *Sargus* larva, like those of all other Stratiomyids, is said to have only eleven post-cephalic segments, whereas a lateral view of *Metoponia rubriceps* shows that twelve segments are actually present. From a dorsal aspect only eleven segments are seen (Text-fig. 1), and in ventral view another segment is not readily distinguishable. But, when viewed laterally, it is seen that what appears to be the terminal segment, consists, really, of the imperfectly fused eleventh and twelfth, the twelfth segment being directed ventrally, and divided off from the eleventh by a very oblique line (Text-fig. 6).

The segments are all much broader than long, and of uniform width from the second to the tenth; the terminal segments are slightly narrower. The body is elongate, and, in the older larvae, flattened dorso-ventrally. Younger larvae are more nearly cylindrical, larvae of 4 mm. length having a lateral diameter of 1.0 mm., and a dorso-ventral of .93 mm., whereas the corresponding proportions in a larva of 9 mm. length are 2.0 and 1.6 mm. In transverse section the segments have the shape of a bi-convex lens, with the lateral edges expanded into tumid ridges, marked off from the main body, on both surfaces, by a shallow groove. The eleventh segment is somewhat spatulate, with a median and two lateral convexities on the dorsal surface (Text-figs. 1 and 15). Between the segments, the body is slightly constricted, and, in contraction, the segments are imbricated, overlapping from behind forward in front of the fourth segment, and in the reverse direction from the fourth backward. The incisure between the tenth and eleventh segments is strongly arched forwards (Text-fig. 1).

At the anterior extremity is situated the dark brown, strongly chitinised head, which can be retracted into the first thoracic segment.

Integument.—The whole body is invested in a thick, firm integument of the typical stratiomyid type, consisting of large hexagonal plates, separated by granular areas, which cause a grating sound when scratched with the point of a needle (Text-fig. 9). This armoured coat is strongly impregnated with carbonate of lime. Fixation in Carl's fluid, containing glacial acetic acid, gives rise to a rapid and long continued evolution of gas, proved, with baryta water, to be CO_2. Along the posterior margin of each segment (Text-fig. 10) are two or three transverse rows of specially differentiated amber-coloured plates

(*pl*), which probably mark the points of insertion, internally, of the segmental muscles, as described by Viallanes (1882, p. 7). Similar plates are numerous on the eleventh segment, and in the region of the anus. The latter is in the



Text-fig.9. Spiracle of abdominal segment, and portion of the integument surrounding it. (x 210).

Text-fig.10. View of lateral ridge of a segment, showing spiracle on dorsal side, and arrangement of lateral bristles. (x 18).

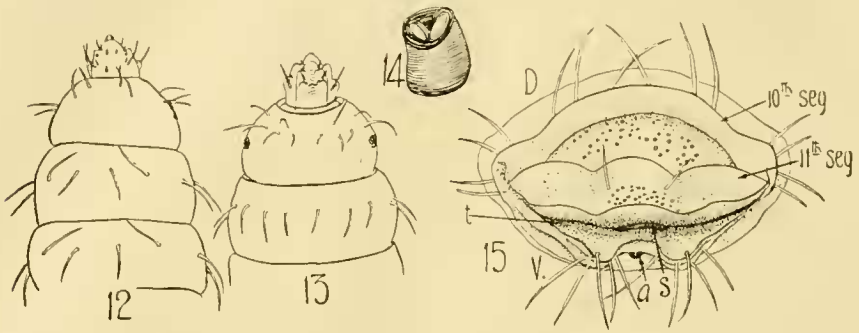
Text-fig.11. Portion of a bristle, broken off its base (*b*). (x 210).

form of a longitudinal slit, with thick, strongly chitinised lips, situated medianly on the ventral surface of the end segment. From it a deep groove runs backwards to connect with a terminal transverse split (Text-figs. 2, 8).

Bristles.—Long, stiff, black hairs, or, rather, bristles, are present on all the segments. They are very brittle, and are easily broken off at the base, so that their regular arrangement on the body is best seen on a freshly-moulted specimen. In cross-section they are circular, and each consists of an outer brownish-coloured sheath enclosing a dark solid core, which extends almost to the tip (Text-fig. 11). Most of them taper to a fine point. As in the larvae of the genera *Sargus*, *Chloromyia*, *Microchrysa*, and in *Pachygaster minutissima* Zetr., and *Xylomyia maculata* Wied., each abdominal segment from the first to the seventh bears a transverse row of six, equally long, backwardly directed bristles on each surface. The dorsal hairs are slightly longer than the ventral, the average lengths in larvae of 2 mm. width being about 0.7 and 0.6 mm. respectively. On the dorsal surface they all slope inward, towards the mid-dorsal line; those on the ventral surface form groups of three on each side, the three converging posteriorly (Text-fig. 8). On each of the lateral ridges of the same abdominal segments is a group of four bristles, in two rows, set diagonally across the ridge, and sloping upwards and backwards from the dorsal side (Text-fig. 10). The two of the anterior row are short and blunt; the other two, which are arranged alternately with them, are more than twice as long, and sharply pointed. They are usually longer than the other body bristles, and increase in length posteriorly, the longest of them, on the seventh abdominal segment, measuring 0.8 or 0.9 mm. There is a pair of short pointed bristles on the middle of the dorsal surface of the eighth segment, a longer pair on its lateral ridges, and a transverse row of four on the ventral surface. The lower of the two lateral bristles is inserted just at the end of the terminal split.

Close to the anus, on each side, and directed towards it, is a single short bristle. Further back a pair of bristles is situated on the ridge on each side of the anal groove, and another pair on the terminal apex of the ridge, where it bounds the transverse split (Text-fig. 8).

Among these large bristles there occur on the body a few very small colourless bristles, about 0.05 mm. long. Eight of them are in constant association with the bristles bounding the transverse split, in which the aperture of tracheal chamber opens. Two are inserted above and two below the aperture, one close beside the bristle at the angle of the split, and one between each pair of apical bristles (Text-fig. 7). A similar hair occurs laterally on both surfaces of every segment, just beyond and below the outermost bristles of the transverse rows.



Text-fig.12. Anterior end of larva. Ventral view. (x 12).
Text-fig.13. ,, ,, Dorsal view. (x 12).
Text-fig.14. Prothoracic spiracle. Surface view. (x 112).
Text-fig.15. View looking down on posterior end of larva. (x 22). *t*, terminal groove; *s*, spiracular aperture; *a*, anus; D, dorsal surface; V, ventral surface.

The arrangement of the bristles on the thoracic segments is somewhat different. On the dorsal surface of the first segment there are two transverse rows, with four small bristles in the first row, six in the second (Text-fig. 13). Meso- and meta-thoracic segments each bear the usual row of six on the dorsal surface. But on the ventral surfaces of the three segments there are only four. On the prothoracic segment these are arranged in two rows, on meso- and meta-thorax in a single row, with the two outer bristles directed forwards instead of backwards (Text-fig. 12). The lateral ridges bear each only a single pair of long bristles, but a small colourless hair, similar to the other microscopic hairs on the body, is also present.

Except in the relative length of the bristles, the smallest larvae found (2 to 3 mm.) are exactly similar to the fully-developed larvae. The bristles are proportionally much longer in the younger larvae, and give them a distinctly hairy appearance. The two long bristles of the lateral ridges are specially well developed, while the two smaller ones are very minute.

The Head.—The head is short, and broadly conical, having a basal width of 0.48 mm., and a length of 0.57 mm. in larvae of 8 mm. length. It is deep yellowish-brown in colour, darkest in front, where it is most strongly chitinised, and divided into a median and two lateral lobes (Pl. xxvii., figs. 1, 2). The median lobe terminates in a small, cylindrical process, with smooth surface, and

bluntly rounded tip. The lateral lobes are situated some distance further back, 0.15 mm. behind the median process. They are short, broad, rounded "bosses," with rugose surface, composed of thick, dark chitin. Behind them, in the posterior third of the head, there is, in the clear, membranous area on each side, a prominent eye-swelling, bounded by a semi-circular membrane. The greater part of the upper surface of the head is covered by a broad sclerite, presenting an irregular series of transverse ridges, with two specially prominent ones on each side (Pl. xxvii., fig. 1). In front of each of these is a small bristle. Another very small bristle is situated on each side of the median process. At the base of the eye-swelling on both dorsal and ventral sides is a stout prominent hair, about 0.32 mm. long. The ventral hair is accompanied by another very small one. Two smaller bristles, of unequal length, are situated in front of them, close to the ventral base of the lateral "boss." On either side of the mid-ventral line, on a level with the lateral "bosses," is another small bristle, and a similar pair is situated further back, towards the base of the head. There are, thus, six pairs of bristles on the ventral surface, and four pairs on the dorsal surface. All the bristles appear to be sensory in character, but none of them correspond to the jointed antennae which are said to be present on the heads of Stratiomyid larvae. If true antennae exist I have not been able to detect them. In the figure which Brauer gives of a *Sargus* larval head, he marks the lateral lobe "Fuhler," but in the *Metoponia* head this is clearly a portion of the chitinous skeleton. However, there is, on the ventral base of each lateral lobe, a curious structure having much the appearance of a spiracle. It is in the form of a shallow, cup-shaped projection, with a row of tooth-like processes projecting from its inner margin, into its cavity (Pl. xxvii., fig. 2).

The mouth parts are small, and difficult to distinguish, on account of the dark colour and density of this part of the chitinous skeleton. They consist of the median process, which probably corresponds with the structure called by Becker (1910) the upper lip, and two pairs of small, pointed scale-like processes lying close against its under side (Pl. xxvii., fig. 2). The two inner processes are bent over towards each other at the tip, and so are somewhat hook-shaped; the outer are sharply pointed. In structure and arrangement, these mouth parts differ considerably from those described by Becker and others for Stratiomyid larvae, and will be considered more fully in a later paper.

Stigmata.—The two prothoracic spiracles, situated close to the lateral margins of the segment, are large and prominent, dark brown in colour, and slightly salient. They appear to be exactly similar to those of *Pachygaster minutissima*, as described by Tragardh (1914). Two narrow oval slits open on a flat surface, with a regular rounded outline, below which lies a larger area of chitin, of distinctive shape, shown in Text-fig. 14. A pair of very small spiracles is situated on the meta-thoracic and the first to the seventh abdominal segments, in the lateral grooves, a little in front of the middle of the segment. They are of simple structure, having a triangular aperture, bounded by a dark brown circular area (Text-fig. 9). The two main tracheal trunks terminate internally, in the last segment, in large spiracles, which open into a median pear-shaped air chamber. This communicates with the exterior by a narrow aperture with chitinous lips, situated at the bottom of the deep transverse split at the posterior end (Text-fig. 15). If the supposition that a twelfth segment is really present, is correct, this split would represent the dorsal incisure between the eleventh and

twelfth segments, and the position of the posterior spiracles would correspond with that in which they are usually found in dipterous larvae having twelve segments.

Pupal metamorphosis.

In this paper I do not propose to do more than indicate in a general way the external features of the development of the pupa.

Jusbaschjanz (1910) has studied, in great histological detail, the metamorphosis of various internal organs in the larva, but says very little about the pupa, and, so far as I am aware, no description exists of the stages in the gradual change of form during its growth from the larva.

As the pupa is hidden inside the old larval skin during the whole course of its development, it is necessary to remove the skin in order to study it. At a very early stage in its metamorphosis, the pupa comes to lie free inside the skin, surrounded by a watery fluid, and retaining its connection with the skin only by means of the stigmata on each segment. Its removal, therefore, is an easy matter, and is rendered still easier by the existence of lines of weakness in the skin at the points where it is subsequently split open by the emerging fly. Old, empty larval skins show the lines of cleavage very well. By a clean, circular cut round the upper part of the second thoracic segment, the portion of the case anterior to this is separated off in the form of a sort of "head-cap." In the mid-dorsal line, the circular cut dips to form a slight angle, and from this point a straight split extends down to the upper part of the first abdominal segment, where it meets a second transverse split extending nearly across the full width of the dorsal wall. After the emergence of the fly, the edges of these splits fit closely and evenly together, owing to the rigidity of the walls, so that the skin has the appearance of an entire case, with a circular aperture at one end (Text-fig. 4).

These natural lines of cleavage are found to be present from the earliest stages of pupation. The "head-cap" is easily removed by light pressure with the point of a needle, and a similar pressure opens up segments two to four, mid-dorsally, in a longitudinal direction, then circularly round the fourth segment (Text-fig. 16), so that this portion of the skin, forming a "thoracic band" can be stripped off in a single piece. By carefully cutting along the mid-dorsal line of the abdominal larval skin, the pupa can be removed, still enclosed in a delicate, transparent pupal membrane.

In the earliest stage of a female pupa removed in this way (Pl. xxvii., fig. 3) pupal head and thorax have become differentiated, but the abdominal segments still retain the larval shape, and differ from those of the larva only in the character of the integument, and in the presence of stout, projecting spiracles with brown chitinised tips. With this exception, the entire pupa is very soft, and pure white. No trace remains of the hexagonal armoured plates of the larval skin, or of the bristles, or other integumental structures. The enclosing membrane fits closely over the body, and, except where it is raised into "blisters" over developing appendages, it is not apparent.

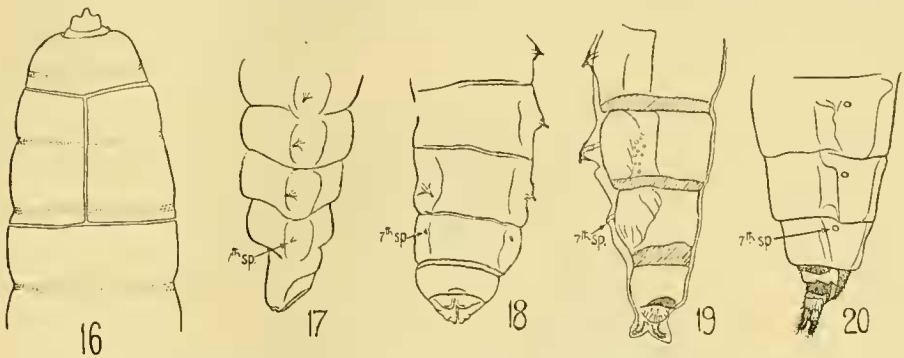
The position of the mouth parts is indicated by blister-like swellings of this character. Already well defined at this early stage, they form, at later stages, much more conspicuous features of the pupal head, than do the mouth parts on the adult.

The three thoracic segments are still distinct, and the appendages of each are folded closely against its ventral surface, and do not extend beyond the seg-

ment from which they originate. In the specimen shown in Pl. xxvii., figs. 3 and 4, the appendages had been stretched out for examination, and had not completely resumed their normal closely-packed condition when figured. The segments of the antennae and the limbs are indicated only by faint grooves in the uniform, finely-granular, white matter of which all the appendages are composed at this stage.

The halteres are relatively much larger than in the imago, and appear clearly as the rudiments of meta-thoracic wings (Pl. xxvii., fig. 4).

The first appearance of colour on the body is in the region of the eye rudiments. These soft, white, rounded prominences assume a yellowish tinge about the same time that the thoracic appendages, still white and indistinctly divided into segments, unfold, and extend down over the ventral surface of the body. As the eyes deepen in colour, the yellow tinge extends over that part of the head which is orange-coloured in the adult female.



Text-fig.16. Diagram showing way in which larval case of pupa is opened up. (x 11).
Text-figs.17–20. Metamorphoses of posterior end of larva during pupation. (x 12).
Fig.17. Lateral view of early stage. Fig.18. Ventral view of later stage.
Figs.19–20. More advanced pupae, lateral views. 7th sp., spiracle of 7th abdominal segment.

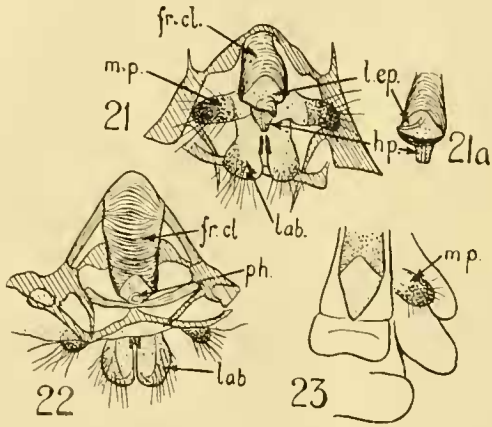
At this stage the terminal abdominal segment loses its larval character, and becomes slightly bilobed at the tip (Text-fig. 18), while a bilobed protuberance grows out from its ventral surface. The latter probably originates from the upper, or eighth abdominal segment, while the bilobed tip belongs to the ninth (fused) segment.

The development of this terminal, or fused eighth and ninth segment, into the external genitalia of the adult fly, is the most noticeable feature of later pupal growth. It has been followed out in more detail in the female than in the male, and is shown in Text-figs. 17 to 20. The male pupae secured did not show the same range of developmental stages, but eight distinct abdominal segments are present in all.

Other changes take the form of depositions of colouring matter, and of chitin in various parts of the body, as the segments of the appendages become more clearly defined; and the outgrowth of hairs on these segments, and of a fine pubescence on the abdomen (Pl. xxvii., fig. 6). The wing sheaths lie flat against the ventral surface of the body, and cover the first and second abdominal

segments. Within them the much crumpled and folded wings can be seen, very dark in colour. The first pair of legs extends down to the tip of the wing, the second pair to the middle of the third segment, and the third pair almost to the fifth segment. The limb sheaths fit loosely over them, and are slightly constricted at the level of each joint.

The form of the sheaths for the mouth parts is shown in Pl. xxvii., fig. 7. They consist of four thin-walled vesicles, two central, upper and lower, with enlarged bilobed extremities, and a narrower one on each side, bluntly rounded at its extremity, and with a small secondary lobe attached to its upper surface. Through their walls it is possible to see portions of the developing mouth parts, at first pale yellow in colour, later darkening to a deep brown. There is a certain amount of rigidity in the pupal skin, so that the vesicles retain their shape unsupported by the underlying organs, these being much smaller than their covering. When the latter is removed it is found that the lateral vesicles enclose the maxillary palps, and the lower median vesicle the "proboscis," its bilobed extremity forming the sheath for the labellae. The parts enclosed by the upper vesicle are very small and inconspicuous, but a careful examination of them



Text-fig.21. Mouth parts of pupa dissected out from pupal sheath, surface view. (x 57).
Text-fig.21*a*. Labrum epipharynx of same.
Text-fig.22. Back view of the same.
Text-fig.23. Portion of sheath of mouth parts, showing enclosed labrum-epipharynx, and palp.
fr.cl., fronto-clypeus; *l.ep.*, labrum-epipharynx; *hp.*, hypopharynx; *m.p.*, maxillary palp; *ph*, pharynx; *lab*, labella.

when dissected out (as shown in Text-figs. 21, 22) reveals the presence of most of the structures described by Peterson (1916), and shown in his figures of *Stratiomyia apicula*. Within the proximal end of the vesicle is a small saddle-shaped piece of chitin, the fronto-clypeus, which supports, on its lower, inverted V-shaped margin, a triangular, beak-like process, projecting outward from the face, the labrum-epipharynx (Text-fig. 21*a*). In the pupa, the line of junction between the constituent parts is still visible, and the underlying epipharynx is clearly distinguishable from the labrum. Lying below this structure, and still quite separate from it, is the thin grooved hypopharynx. In the imago (Pl.

xxvii., fig 8) its basal portion is united with the labrum-epipharynx, to form the basi-proboscis, and the free distal end is scarcely distinguishable.

The tip of the labrum-epipharynx, in the pupa, does not reach beyond the proximal half of the sheath enclosing it (Text-fig. 23), and the existence of the enlarged, bilobed, distal portion is puzzling. No structure is contained within it at any stage of development. The double nature of the sheath enclosing the maxillary palp is also peculiar, but seems to suggest the presence, originally, of well-developed maxillae, with their galeae and laciniae.

Between the lateral sheaths, just below the upper median one, there are, in the very early pupal stage figured in Pl. xxvii., figs. 3 and 4, two small, thin, needle-like, chitin pieces, which are not enclosed in sheaths. These structures, which do not appear in later stages, would seem, from their position, to represent rudimentary mandibles, though no trace of mandibles exists in the imago.

Other swellings of the pupal skin, for which no apparent reason exists, occur on the head. A small double vesicle is situated between the base of the antennae, and the sheaths for the mouth parts (Pl. xxvii., fig. 7). Just below the eye on each side, in the position of the gena, is a prominent, downwardly-projecting, hollow vesicle.

Stigmata.—A pair of lateral spiracles is present on each abdominal segment from the first to the seventh. The first six pairs are very prominent from the earliest stages of pupal development, and are of complicated structure. The greater portion of each one lies outside the body wall, in the region between it and the pupal skin, which is here raised into a sharp peak, and strengthened by a funnel-shaped piece of chitin. The wide mouth of the funnel faces inwards, and serves to protect the underlying stigmatic apparatus. This consists of a pear-shaped bulb with thick muscular walls, penetrated by a fine lumen, and terminating in a long slender tube, with strongly chitinised walls, which runs through the neck of the funnel, and extends out to the larval skin (Text-fig. 19). The tip of the spiracle appears on the outer surface of the larval skin as a dark brown projection in the region of the larval stigma. A slender tracheal tube, given off from the base of the bulb, and opening independently on the pupal skin, is probably the original larval tracheal tube, the pupal spiracle being a secondary growth. These structures will be considered more fully in a later paper, dealing with the tracheal system of larva and pupa. A trachea of the ordinary type connects the base of the stigmatic bulb with a circular aperture in the body wall. Shortly before the emergence of the imago, this tube becomes detached from the body, and the whole stigmatic apparatus is left behind in the pupal skin (Pl. xxvii., fig. 9). The only trace of it which remains on the body, is a wide, deep hole, with chitin rim, on the lateral margin of each segment (Text-fig. 20).

The spiracles of the seventh pupal segment differ from the rest. They project very little beyond the body, and are of simple structure, lacking the great development of chitin supports. The reason for this is seen when the larval skin is dissected away from the dorsal wall of the pupa (Pl. xxvii., fig. 5). The first six abdominal segments correspond exactly with the segments of the larva, and are in close contact with the larval walls in the region of the spiracles. But the terminal segments undergo a considerable change in size and shape during metamorphosis, becoming telescoped to a certain extent, and reduced in width; so that a wide space is left round the posterior end of the pupa, and the seventh pair of spiracles is not opposite the corresponding pair in the larval skin, and cannot reach the exterior to function in breathing.

All the figures, for both Plate and Text-figures, were drawn at stage level, with the help of Zeiss camera lucida, and Zeiss and Reichart oculars and objectives.

Type specimens of larva, and male and female pupae and bred specimens of both spring and autumn broods have been deposited in the Australian Museum, Sydney. [Specimens Nos. K 43304—08.]

Figures of bred specimens, both male and female, are shown on Plate xxviii.

List of the Species of Stratiomyiidae which have been Observed in the Earlier Stages, with References to the Literature Relating to These.

[To avoid unnecessary repetition the authors are quoted here only with date and page of work. The complete reference will be found in the literature list at the end, which is arranged in chronological order. The names of the species are those given in the descriptions referred to. No attempt has been made to deal with synonymy.]

Beris chalybeata Forst.—Walker, 1851, pp. 11, 12; Schiner, 1864, p. 24; Brauer, 1883, p. 58; Lundbeck, 1907, p. 69.

Beris spp.—Williston, 1908, p. 165; Verrall, 1909, p. 199.

Chloromyia formosa Scopoli.—Lundbeck, 1907, pp. 65-66, fig. 26; Verrall, 1909, p. 189.

Chorisops (*Actina*) *tibialis* Meigen.—Handlirsch, 1883, pp. 243-245, figs. 1-4; Brauer, 1883, p. 58; Lundbeck, 1907, p. 70; Verrall, 1909, p. 204.

Chrysomyia formosa Zett.—von Roser, 1834, p. 267; Cornelius (*Sargus formosus* Schrank), 1860, pp. 202-204, t. ii.; Brauer, 1883, pp. 58 and 23.

Chrysomyia polita Linnaeus.—Réaumur, 1742, t. 14, fig. 6; von Roser, 1834, p. 267; Bouché, 1834, p. 49; Scholz, 1848, pp. 1-3, 10; Beling, 1882, p. 188; Brauer, 1883, p. 58.

Clitellaria ephippium Fabricius.—Meigen, 1818, iii., p. 130; von Roser, 1834, p. 267; Westwood, 1840, p. 533, fig. 127, 8; Zeller, 1842; Markel, 1844, pp. 266, 478-480; Scholz, 1848 (?); Jaennicke, 1866, p. 226; Brauer, 1883, p. 58 (*Ephippium thoracium*); Verrall, 1909, p. 83.

Ephippium albitarsis (?) Bigot.—Froggatt, 1896, p. 84, Pl. ix., figs. 12, 13.

Geosargus (*Sargus*) spp.—Williston, 1908, p. 165.

Hermetia albitarsis Fab.—Brauer, 1883, p. 58.

Hermetia illucens L.—Bellardi, 1861, p. 26; Brauer, 1883, p. 58; Dunn, 1916, pp. 59-61.

Hermetia spp.—Williston, 1908, p. 165.

Hoplodonta viridula Fabricius.—Lundbeck, 1907, pp. 57-58.

Microchrysa polita Linnaeus.—Lundbeck, 1907, p. 67; Verrall, 1909, p. 192.

Microchrysa spp.—Lundbeck, 1907, p. 67.

Myiochrysa spp.—Williston, 1908, p. 165.

Nemotelus pantherinus L.—Lundbeck, 1907, p. 26, fig. 7.

Nemotelus uliginosus Linnaeus.—Haliday, 1857, p. 194; Brauer, 1883, pp. 58, 23.

Nemotelus spp.—Lundbeck, 1907, pp. 23-24; Williston, 1908, p. 165.

Odontomyia angulata Panz.—Lundbeck, 1907, p. 56.

Odontomyia argentata Fabricius.—Zeller, 1842, col. 807; Zeller, 1846, iii.; Lundbeck, 1907, p. 51.

Odontomyia hydroleon Linnaeus.—De Geer, 1778, vi., Pl. 9, fig. 4; Brauer, 1883, pp. 58, 23.

Odontomyia ornata Meigen.—Réaumur, 1742, Pl. 25; Zeller, 1842; Jaennicke, 1866, p. 218; Brauer, 1883, p. 58, fig. 23c; Lundbeck, 1907, p. 54, figs. 20-21; Verrall, 1909, p. 143.

Odontomyia tigrina Fabr.—Lundbeck, 1907, p. 50; Jusbaschjanz, 1910, p. 685.

Odontomyia viridula Fabricius.—Scholz, 1848, p. 34; Brauer, 1883, p. 58; Jusbaschjanz, 1910, p. 685.

Odontomyia spp.—Lundbeck, 1907, p. 48; Williston, 1908, p. 165; Verrall, 1909, p. 130.

Oxycera meigenii Staeg.—Heeger, 1856, p. 335; Brauer, 1883, p. 58.

Oxycera morrisii Curtis.—Haliday, 1857, p. 193; Verrall, 1909, p. 102.

Oxycera trilineata Linnaeus.—Heeger, 1856, p. 335; Brauer, 1883, p. 58; Lundbeck, 1907, pp. 31-32, 34, fig. 14.

Oxycera spp.—Bremi, 1846, col. 164; Haliday, 1857, p. 193, Pl. 11; Brauer, 1883, p. 23.

Pachygaster ater Panz.—Meigen, 1818, vi., p. 344; vii., p. 104; Macquart, 1823; St. Fargeau, 1825, p. 779; Schilling, 1829, p. 94; Scholz, 1848, p. 1-3, 19; Dufour, 1841, p. 264; Heeger, 1853, fig.; Brauer, 1883, p. 58; Verrall, 1909, p. 71.

Pachygaster leachii Curtis.—Perris, 1870, p. 212; 1876, p. 180; Verrall, 1909, p. 78.

Pachygaster meromelas Dufour.—Dufour, 1841, pp. 264-266, figs. 17-19.

Pachygaster minutissimus Zett.—Zetterstedt, 1851, viii., p. 2961; Brauer, 1883, p. 58; Lundbeck, 1907 (*P. minutissima*), p. 21; Tragardh, 1914, pp. 192-196, figs. 3-5; Verrall, 1909, p. 68.

Pachygaster orbitalis Wahl.—Verrall, 1909, p. 75, fig. 99.

Pachygaster pini, Perris.—Perris, 1870, p. 210, ten figs.; Brauer, 1883, p. 58.

Pachygaster tarsalis Zett.—Lundbeck, 1907, pp. 20, 22, fig. 4; Verrall, 1909, p. 72, fig. 100.

Pachygaster spp.—Westwood, 1840, p. 532, figs. 127, 129; Zetterstedt, 1851, viii., p. 2961; Brauer, 1883, pp. 58, 23; Williston, 1908, p. 165; Verrall, 1909, p. 66.

Sargus bipunctatus Scopoli.—Réaumur, 1742, p. 59, Pl. 14, fig. 4, Pl. 22, figs. 5-8; Brauer, 1883, p. 58, fig. 24.

Sargus cuprarius Linnaeus.—Lyonet, 1832, Pl. 17, figs. 21-24, 29; Bouché, 1834, p. 48, Pl. 4, figs. 31-36; von Roser, 1834, p. 267; Westwood, 1840, p. 533, fig. 127, 10; Dufour, 1846 (Comptes rendus), p. 318-319; Beling, 1882, p. 187; Brauer, 1883, p. 58; Lundbeck, 1907, p. 61; Verrall, 1909, p. 184.

Sargus flavipes Meigen.—Lundbeck, 1907, p. 64.

Sargus formosus Schrank.—Cornelius, 1860, pp. 202-204, Pl. 2.

Sargus iridatus Scop.—Lundbeck, 1907, p. 62, fig. 24.

Sargus spp.—Perris, 1870, p. 206; Lundbeck, 1907, p. 60; Verrall, 1909, p. 165.

Stratiomya anubis Wiedem.—Cros, 1911, pp. 99-103, figs.

Stratiomys chamaeleon Linnaeus.—Frisch, 1720, p. 10; Swammerdam, 1737, Pls. 39, 40, 41; Réaumur, 1742, Pl. 22; Sparmen, 1804; Schrank, 1793, pp. 7-25, Pl. 3, figs. 1-9; Geoffroy, Entom., ii., p. 17; Westwood, 1840, p. 532; Leydig, 1860, p. 157, fig.; Leydig, 1861, p. 39; Brauer, 1883, p. 58, figs. 22, 24; Mik, 1896, pp. 110-111; Florentin, 1899, p. 274; Jusbaschjanz, 1910, p. 685; Fanthom and Porter, 1913, pp. 609-620, Pl. xli.; Verrall, 1909, p. 152.

Stratiomyia potamida Meigen.—Fanthom and Porter, 1913, p. 609-620, Pl. xli.

Stratiomyia spp.— Lundbeck 1907, pp. 14-15, 41, 74.

Stratiomys furcata Fabr.—Zetterstedt, 1851, i., p. 135; Brauer, 1883, p. 57, fig. 23*a*; Lundbeck, 1907, p. 44, fig. 17.

Stratiomys longicornis Scop.—Scholz, 1848, p. 34; Friedenfels, 1880, p. 164; Brauer, 1883, p. 57, fig. 23*b*; Henneguy and Binet, 1892, lxi., pp. 309-316, Pl. 6; Lundbeck, 1907, p. 43; Cros, 1911, p. 101.

Stratiomys strigata Meigen (*nec* Fabricius) = *S. riparia*.—Kawall, 1867, p. 124.

Stratiomys strigosa.—Henneguy and Binet, 1892, cxiv., pp. 430-432.

Stratiomys spp. (Habitat).—Packard, 1871, p. 102; also in Amer. Nat., ii.; Lucas, 1879, p. 142; Laker, 1880, pp. 167-168; Brongniart, 1881, p. 419; Griffith and Packard, 1882, pp. 599-600; Pearson, 1884, p. 1287; Johnson, 1895 p. 229; Williston, 1908, p. 165.

Stratiomys spp. (Morphol.).—Kunckel d'Herculais, 1879, pp. 491-494; Viallanes, 1885, pp. 75-78; Vaney, 1900, p. 360.

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Explanation of Plates xxvii.-xxviii.

Plate xxvii.

Metamorphosis of *Metoponia rubriceps* Macq.

Fig. 1. Head of larva, dorsal view. × 45.
Fig. 2. The same, ventral view. × 45.
Fig. 3. Pupa; early stage. Ventral view. × 14.
Fig. 4. The same, lateral view. × 14.
Fig. 5. Dorsal wall of larval case cut away to show the enclosed pupa. × 7.
Fig. 6. Pupa; Fairly advanced stage. × 14.
Fig. 7. Head of pupa, enveloped in pupal sheath. × 28.
Fig. 8. Mouth parts of imago. × 28.
Fig. 9. Posterior end of pupal sheath, removed from larval case. × 9.

Plate xxviii.

Metoponia rubriceps Macquart.

Fig. 1. Bred specimen of male. Emerged April. Natural size, 5.3 mm. long from head to tip of tail.
Fig. 2. Bred specimen of female, drawn two days after emergence, in November. Abdomen extended to much greater length than is found in most captured specimens. Natural size, 14 mm. long from head to tip of tail.
Fig. 3. Abdomen of a captured female, dorsal view, showing the more usual appearance.